Understanding The GLAST Burst Monitor Detector Calibration:
A Detailed Simulation Of The Calibration Including The Environment

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Abstract. The GLAST Burst Monitor (GBM) is the secondary instrument on NASA's next Gamma-ray mission GLAST. It will enhance the capabilities of GLAST by locating and detecting cosmic gamma-ray bursts at lower energies by the use of 12 NaI detectors (energy range 10 keV to 1 MeV) and 2 BGO-detectors (energy range 150 keV to 30 MeV). GBM was built in a close collaboration between the MPE and the Marshall Space Flight Center (MSFC). The angular and energy response of each GBM detector has been calibrated using various radioactive sources at different incidence angles relative to the detector in a laboratory environment at the MPE in 2005. To facilitate the understanding of the reconstruction of the detector response, a detailed simulation of the whole laboratory environment and the setup of the calibration source were performed. A modified version of the CERN GEANT 4 simulation software (provided by collaborators at the Los Alamos National Laboratory) was used.

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CALIBRATION SETUP

The full environment of the calibration setup was modeled (see Figure 1). To disentangle the contribution of the various parts of the environment to the scattered radiation, all components could be activated or deactivated for interactions of the radiation. In addition, complete detailed models of a NaI detector, a BGO detector, and their mounting brackets as they are used on the spacecraft were created. The complex holding structure, which enabled a rotation of the detectors around all three axes during the calibration, was also included in the model. The detector mounting that rested on a wooden stand raising it about one meter above the laboratory floor, could be rotated around three axes to change the angle of the incident radiation.

The radioactive sources used for the calibration were placed onto a source holder at a fixed position near the middle of the room. This source holder was also mounted on a wooden stand. The distance from the detector to the source was 1.16 m. The following radioactive calibration sources were used and simulated (main energies in MeV):

^{109}Cd (0.022), ^{241}Am (0.059), ^{57}Co (0.122, 0.134), ^{203}Hg (0.279), ^{137}Cs (0.662),
^{51}Mn (0.835), ^{22}Na (0.511, 1.275), ^{88}Y (0.898, 1.836)

The radioactive material of the calibration sources was contained in a sphere of about 1 mm diameter in the center of a flat plastic disc. This disc was mounted to the source holder made from PVC.

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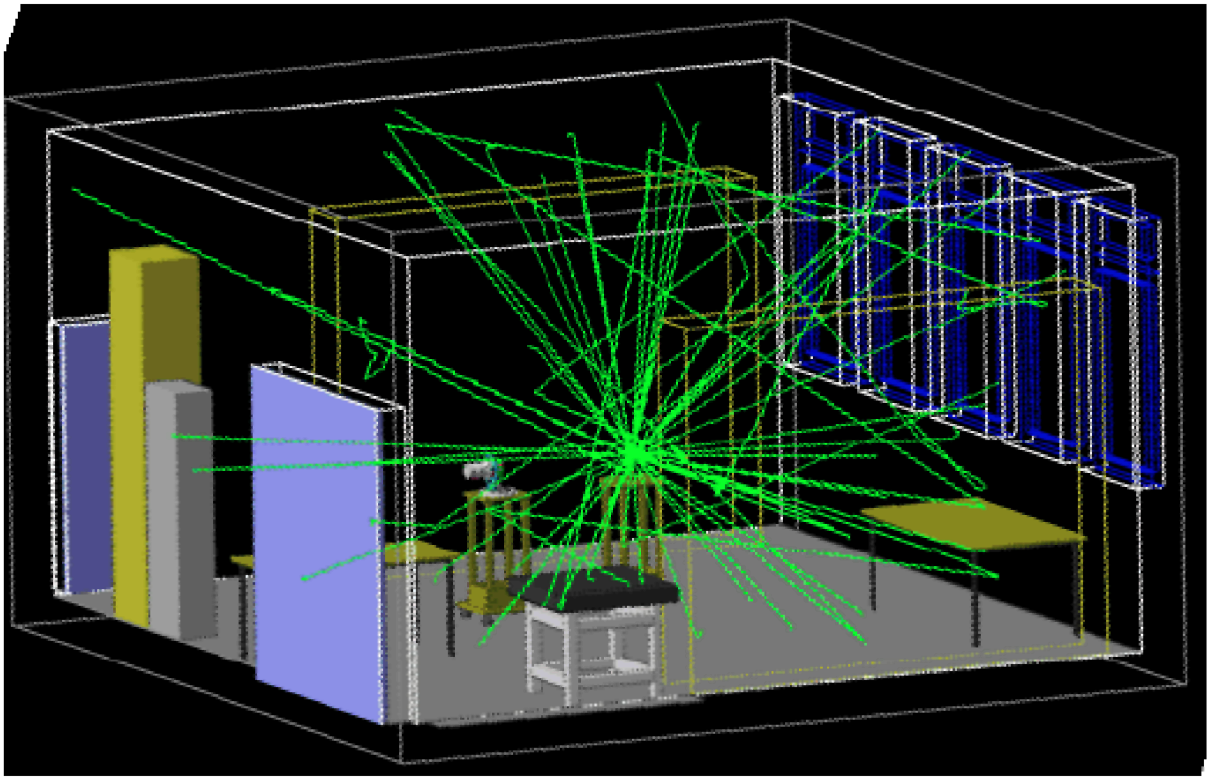

FIGURE 1. 3D-illustration of the scattering of the isotropic radiation of a ^{22}Na source. For clarity, only the first 100 interactions are shown. The laboratory environment (walls, windows, furniture, floor, ceiling, detector holding structure, source holder etc.) was simulated in great detail to find out the contribution of the various parts to the scattered radiation.

SCATTERING OF RADIATION

A significant part of the radiation emitted isotropically from a source is scattered by various objects in the laboratory, including the air. With increasing energy of the radiation, an increasing fraction of the scattered radiation reaches the detector and contributes to the source background (i.e. background induced by the isotropic radiation of a source present). At 22 keV, only few percent of the detected radiation are scattered photons. Most photons reach the detector directly. But at 1.275 MeV a significant part of the detected radiation is from scattered photons. Table 1 summarizes these findings.

TABLE 1. Summary of Results.

	NaI			BGO
Component	**22 keV**	**122 keV**	**1,275 MeV**	**4.43 MeV**
direct in fall	94.0 %	91.0 %	75.0 %	70.0 %
scattered radiation total	6.0 %	9.0 %	25.0 %	30.0 %
walls	< 0.1 %	0.6 %	12.0 %	13.0 %
source holder	4.6 %	7.5 %	3.0 %	2.0 %
source stand	0.1 %	< 0.1 %	< 0.1 %	< 0.1 %
detector stand	< 0.1 %	< 0.1 %	2.0 %	< 0.1 %
floor	< 0.1 %	0.8 %	8.0 %	15 .0 %
other furniture	< 0.1 %	< 0.1 %	< 0.1 %	< 0.1 %
air	1.3 %	< 0.1 %	< 0.1 %	< 0.1 %